Optimizing Rice-Wheat Cropping System: Assessing the Performance of Happy Seeder in Paddy Fields

Abstract:

The study evaluates the Happy Seeder's performance in sowing wheat crops in combined harvested paddy fields in the Moradabad region, aiming to mitigate crop residue burning and promote sustainable agriculture. The rice-wheat cropping system in the Indo-Gangetic region generates significant crop residues after combine harvesting, leading to environmental and health hazards. The Happy Seeder, designed to cut and lift rice straw while sowing wheat, offers a promising solution to manage residues and prevent burning.Various parameters, including forward speed, crop residue condition, and soil bulk density,were investigated as independent variables to assess the Happy Seeder's performance. Results show an actual field capacity of 0.23 to 0.29 ha/hr, with fuel consumption ranging from 4.12 to 4.40 l/h at different speeds. Field efficiency varied from 43.4% to 65%, with the best performance at 3.5 km/hr forward speed. Economically, the Happy Seeder proves to be a cost-effective alternative, saving Rs. 613.83 per hectare compared to conventional seed drills. Farmers responded positively to its labor-saving features, timely sowing, and eco-friendly benefits, leading to improved crop growth and higher yields.In conclusion, the Happy Seeder demonstrated efficiency, economic viability, and positive farmer feedback, making it a valuable tool for sustainable agriculture in the Moradabad region and beyond. Its adoption can contribute to residue management, improved soil health, and increased crop productivity, fostering an environmentally conscious rice-wheat cropping system in the Indo-Gangetic region.

Keywords: Happy Seeder, Sustainable agriculture, Crop residue management, Rice-wheat cropping system, Environmental sustainability

Comment [LH1]: Please consider removing this information because in the results, soil bulk density was not mentioned.

Comment [LH2]: This study is based on the testing of the seeders, while the methodology for obtaining farmers' feedback was not described. So, giving the results for that is not acceptable. Please consider explaining the methodology for this part in the method section.

1. Introduction

Rice-wheatis a predominant crop rotation in the Indo-Gangetic region, encompassing vast agricultural areas. In particular, the state of Punjab alone accounts for approximately 26.5 lakh hectares under this rotation. While traditional agricultural practices have long been prevalent, the adoption of no-tillage and minimum tillage technologies has been gaining momentum globally

Comment [LH3]: Do you mean a rice-wheat cropping system? If so, please rewrite that phrase properly.

Comment [LH4]: What do you mean by lakh hectares? Can use you English scale instead because it is easy to understand?

UNDER PEER REVIEW

due to their demonstrated advantages in terms of economic benefits, water conservation, and environmental sustainability**(Patel et al., 2022).**

In the north-western region of India, combine harvesting of rice and wheat is a common practice, resulting in significant amounts of crop residues left in the fields. Approximately 91% and 82% of the total area under rice and wheat crops, respectively, are subject to combine harvesting**(Lohan et al., 2018).** As a consequence, an estimated 22 million metric tons of paddy straw is produced annually in Punjab alone**(Singh, 2018**). Presently, a substantial portion of wheat residue is collected by farmers after combine harvesting using straw combines. However, rice straw, known for its high silica content, holds limited economic value and often remains unutilized. To facilitate timely sowing of wheat, a large portion of rice straw is burned in situ by farmers, which poses serious environmental and health hazards. This practice leads to atmospheric pollution, nutrient loss in the soil, and a decline in soil health and structure**(Parihar et al., 2023)**.

Burning of crop residues, particularly rice straw, has far-reaching consequences, including the loss of valuable nutrients such as nitrogen (N) and sulfur (S) (Kumar, 2015). It is estimated that in Punjab alone, about 2.0 lakh tonnes of N and S in paddy residues are lost during burning, incurring a cost of more than Rs. 200 crores at prevailing prices**(Bhuyan, 2019)**. Additionally, one ton of crop residue burning releases substantial amounts of greenhouse gases, including 1,515 kg CO2, 92 kg CO, 3.83 kg NOx, 0.4 kg SO2, 2.7 kg CH4, and 15.7 kg non-methane volatile organic compounds**(Singh, 2018).**

The adverse effects of crop residue burning, along with the potential benefits of adopting sustainable alternatives, have become a matter of concern for farmers and governments alike**(Bhuvaneshwari et al., 2019)**. To address this issue, the Happy Seeder technology has been developed as a direct drilling machine capable of cutting and lifting rice straw while simultaneously sowing wheat in the bare soil. This innovative approach combines stubble mulching, seed, and fertilizer drilling in a single pass, providing a promising solution to manage rice straw and avoid burning**(Singh and Sidhu, 2014)**.

However, despite the evident economic benefits of the Happy Seeder technology, its widespread adoption has faced challenges. Some hindrances include the initial capital cost and the limited usage period on typical small-sized holdings. Additionally, lack of operational

Comment [LH5]: Please refer to the journal guidelines to see if the citations are bolded or not. Then use the right format throughout the text.

Comment [LH6]: Please be consistent, and check the words "tons" and "tonnes." Which one do you use? And then use the right one across the text.

Comment [LH7]: What do you mean by crores? Please use the word that is internally recognizable.

Comment [LH8]: Please turn number "2" into a subscript, and do the same for other gases.

UNDER PEER REVIEW

knowledge and proper guidelines for calibration, operation, and maintenance have contributed to slower adoption rates.

In this context, the present study aims to evaluate the performance of the Happy Seeder for sowing wheat in combined harvested paddy fields in the Moradabad region. The study seeks to compare the results with conventional seeding methods, assess the cost-effectiveness of the technology, and provide valuable insights to encourage the adoption of sustainable practices in rice-wheat farming systems. By focusing on mitigating crop residue burning and promoting eco-friendly and efficient agricultural practices, this research aims to contribute to the long-term sustainability and prosperity of the region's farming community.

2. Material and methods

2.1 Description of the Happy Seeder

The Happy Seeder, an innovative technique for sowing wheat in paddy fields without burning rice residue, was used for the study. It consists of several major components, including the frame, furrow openers, flails, seed and fertilizer box, seed metering mechanism, fertilizer metering system, drive wheel, depth control wheel, power transmission unit, and seed and fertilizer delivery pipes.

2.2 Experimental Design

The study aimed to evaluate the performance of the Happy Seeder in sowing wheat crops in combined harvested paddy fields in the Moradabad region. To achieve this, the following independent and dependent variables were considered:

The several independent variables were considered to evaluate the performance of the Happy Seeder, an agricultural machine designed for no-tillage farming. The forward speed of the Happy Seeder was manipulated at three different levels: 2.5, 3.0 and 3.5 km/hr. Additionally, the condition of crop residue, measured in kilograms per square meter, and soil bulk density were varied to observe their effects on the machine's operation.Focused on various dependent variables to assess the Happy Seeder's functionality. These included recording the specific gear used during the machine's operation, measuring the fuel consumption throughout the sowing process, calculating the theoretical field capacity to determine the rate of field coverage achieved by the Happy Seeder at different forward speeds. Actual field efficiency was determined by

UNDER PEER REVIEW

Comment [LH9]: Please consider displaying the picture of the happy seeder and its specifications because it is important for the reader to fully understand the equipment.
- This study tested not only one piece of equipment but two. So, please show the pictures of both in the method section, as well as describing their specifications for better understanding.
- Please also provide a layout plot design and statistical tests used to analyze the data.

Comment [LH10]: Article "The" should be removed.

Comment [LH11]: At which depths of soil were soil bulk density? Please specify that.
- After checking the results, soil bulk density was not mentioned, so please remove this information from the method section.

Comment [LH12]: This part is not clear because it is a not full sentence. Please rewrite that to make it meaningful.

calculating the ratio of effective field capacity to theoretical field capacity, providing valuable insights into the machine's real-world performance. Furthermore, the study analyzed the total cost of operating the Happy Seeder, encompassing both fixed and variable costs, to understand the economic implications of its usage. Lastly, the specific crop variety sowed using the Happy Seeder was documented for a comprehensive analysis of its applicability across different crops.By exploring these independent and dependent variables, the study aimed to provide a holistic understanding of the Happy Seeder's operation under varying conditions, helping farmers and agricultural experts make informed decisions about its usage in different agricultural settings.

2.3 Measurement of Different Parameters

Comment [LH13]: Please provide the formula for depreciation costs and information about the prices of both happy seeder and seed drill, as it is important for the calculation of the depreciation costs. Besides that, their lifespan should also be mentioned because it is a criterion for the calculation.

Theoretical Field Capacity (TFC):The theoretical field capacity of the machine is the rate of field coverage that would be obtained if the machine were performing its function 100% of the time at the rated forward speed.

$$TFC\ (ha/hr) = (W \times S) / 10 \quad \ldots (1)$$

Where, W = Width of the machine (m) and S = Forward Speed (km/hr)

Effective Field Capacity (EFC):The effective field capacity is the actual rate covered by the machine based on the total field time.

$$EFC\ (ha/hr) = (A/T) \times TFC \quad \ldots (2)$$

Comment [LH14]: Please double-check this formula. EFC should be calculated by dividing the total cultivated area by the total time spent, so there is no need to multiply that with TFC. After that, please write the correct formula.

Where, A = Area covered (ha) and T = Total time taken (hr)

Field Efficiency (FE):Field efficiency is the ratio of effective field capacity to theoretical field capacity.

$$FE = (EFC / TFC) \times 100 \quad \ldots (3)$$

Fuel Consumption:Fuel consumption was measured using the topping method. The tractor's fuel tank was filled before and after the operation, and the difference was recorded as the fuel consumption.

2.4 Field Test:

UNDER PEER REVIEW

The field testing of the Happy Seeder was conducted at Lodipur Village in Moradabad. The crop chosen for testing was wheat. The complete testing was done in six plots, with three different speeds tested and three replications performed for each speed.

Comment [LH15]: Please double-check the number of plots. As you mentioned, there are three different speeds, each of which was tested in three replicates. So, the total number of plots should be nine. Please double-check that and write the correct number.
- Besides that, please specify the dimension of each plot (length and width), because it is important for testing the equipment.
- Please also specify the number of planting rows that the happy seeder has, as this affects the TFC, EFC, and FE
- Please specify the machinery used for pulling the happy seeder. Is it a tractor or a power tiller? Or does the happy seeder have its own power to move? Please help specify the horsepower.

Test Conditions:The performance of the Happy Seeder was evaluated under varying field conditions and with different operators. The condition of the field included its shape, location, topography, area, soil type, temperature, and sunshine. The operator's skill level and wage were also considered during the testing.

2.5 Cost Analysis:

The cost analysis for operating the Happy Seeder involved the calculation of both fixed and variable costs.The cost analysis for operating the Happy Seeder involved the calculation of both fixed and variable costs. Fixed costs included depreciation, representing the decline in the machine's value over time, and interest, which considered the average investment in the machine. Additionally, the cost of housing the machine, insurance charges, and taxes paid for the machine were considered as fixed expenses.On the other hand, the operating costs comprised variable expenses that fluctuated with usage. Fuel cost was calculated based on the actual fuel consumption during operation. Lubricants, constituting approximately 30-35% of the fuel cost, were accounted for in the analysis. Repairs and maintenance costs, estimated at 5-10% of the initial machine cost, were also considered. Lastly, wages for the workers involved in operating the Happy Seeder were included as a variable cost.By examining both the fixed and variable costs, the cost analysis provided valuable insights into the economic viability and affordability of using the Happy Seeder for sowing wheat crops in combined harvested paddy fields in the Moradabad region.By systematically evaluating the performance of the Happy Seeder under various conditions, this study aims to provide valuable insights into its effectiveness in sowing wheat crops in paddy fields without burning the rice residue, promoting sustainable agriculture practices and residue management.

Comment [LH16]: Please remove this sentence because it is a repetition of the previous sentence.

Comment [LH17]: Please provide a reference to support this statement.

UNDER PEER REVIEW

3. Results and discussion

Comment [LH18]: The study focused on seeding wheat at different speed. So there should be a finding that show seed rates at different speed and between the two seeders.

3.1 Performance Evaluation

The performance evaluation of the Happy Seeder for sowing wheat crops in combined harvested paddy fields was conducted, considering various parameters such as field efficiency, field capacity, and fuel consumption.

The forward speed of the Happy Seeder was investigated as an independent variable, ranging from 2.5 to 3.5 km/hr. This variable was crucial in evaluating performance parameters such as actual field capacity, fuel consumption, and efficiency. The lowest speed of 2.5 km/hr was achieved at the minimum throttle setting of the machine.

Fuel consumption data were collected at different operating speeds for both the Happy Seeder and the seed drill. The results, depicted in Figure 1, revealed varying fuel consumption rates. For the Happy Seeder, fuel consumption ranged from 4.12 to 4.40 l/hr, whereas the seed drill exhibited a range of 2.26 to 3.71 l/hr. interestingly, the lowest fuel consumption was observed at the lowest operating speed, highlighting the significance of speed control in optimizing fuel efficiency during the sowing process.

The actual field capacity was measured in different plots and at various forward speeds, as shown in Figure 2. It was observed that the actual field capacity varied from 0.23 to 0.29 ha/hr for the Happy Seeder and from 0.31 to 0.43 ha/hr for the seed drill. The actual field capacity increased with the forward speed of travel, with the maximum field capacity achieved at the highest speed.

Various field efficiencies were calculated for the Happy Seeder and seed drill, as shown in Figure 3. The minimum field efficiency of 43.4% and 65% was found at 3.5 km/hr for the Happy Seeder and seed drill, respectively. The best efficiency was achieved at 3.5 km/hr for both machines. The main reason for low field efficiency is the time loss in turning operations.

Crop residue was considered as an independent variable, and the amount of crop residue was recorded. The crop residue condition varied from 0.830 kg/m2 to 0.839 kg/m2, representing a heavy condition of crop residue.

UNDER PEER REVIEW

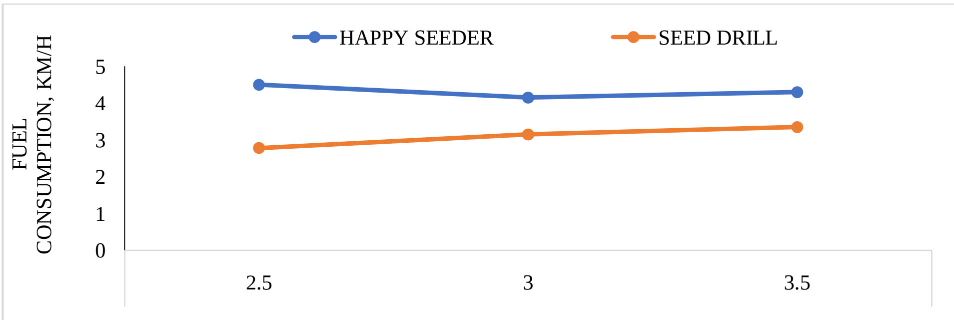

Fig 1: Effect of forward speed on fuel consumption

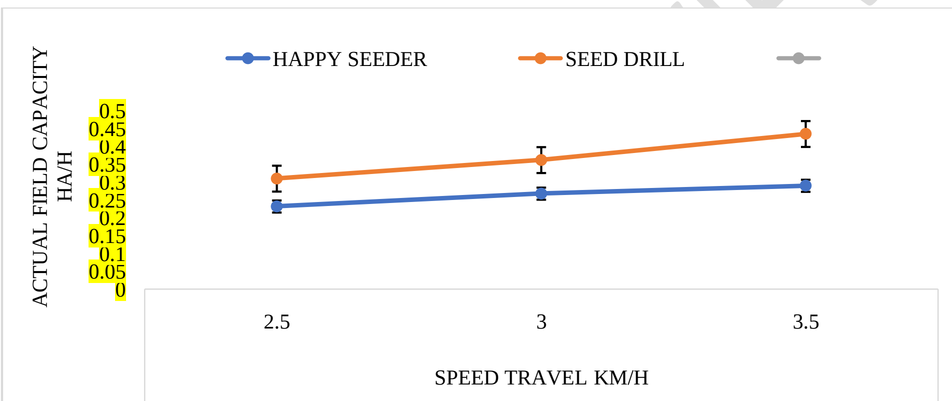

Fig 2: Effect of forward speed on actual field capacity

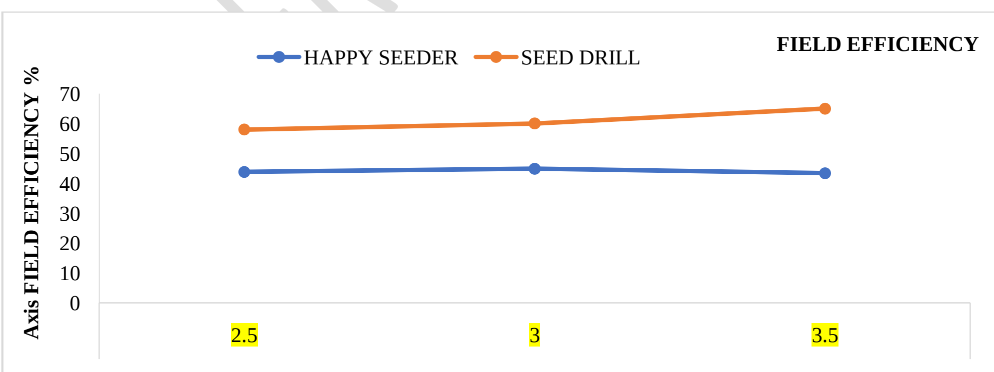

Fig 3: Effect of forward speed on different machine efficiency

3.2 Economic Evaluation

Comment [LH19]: The number displayed on the y-axis is so compressed, so please use a good enough interval to make it look better.

Comment [LH20]: Please refer to the journal guidelines to see if totally capitalized words are allowed. If not, please use the right format.

Comment [LH21]: To support the results for the economic analysis, please display a table that consists of fixed costs, variable costs, and total costs for both planting equipment.

Cost Comparison of Operation with Conventional Method: To compare the cost of operation between the Happy Seeder and the conventional seed drill, several factors were taken into account. For the Happy Seeder, the total cost of operation was calculated by adding the operation cost of the tractor to the operation cost of the Happy Seeder, resulting in Rs. 1079.61. Considering an area covered per hectare of 0.29 ha/hr, the total cost of operation with the Happy Seeder was found to be Rs. 3720.21 per hectare. On the other hand, for the Seed Drill, the operation cost of the tractor was Rs. 512, and the area covered per hectare was also 0.29 ha. Thus, the total cost of operation with the Seed Drill and cultivator combined was Rs. 3106.38 per hectare. The analysis clearly indicates that the Happy Seeder offers economic advantages, saving Rs. 613.83 per hectare compared to the seed drill. This cost-effectiveness makes the Happy Seeder a favorable choice for farmers looking to optimize their agricultural practices and reduce operational expenses.

The Farmers reaction to the Happy Seeder was positive. They appreciated its labor-saving benefits, timely and easy sowing, water-saving features, and eco-friendly nature. The machine's effective weed control was also praised, leading to improved crop growth and higher yields. Overall, the Happy Seeder received favorable feedback from farmers, proving to be a valuable addition to their agricultural practices.

Comment [LH22]: A survey on farmers' perspectives on the testing of the happy seeder was not mentioned in the method. So how the result was obtained was unclear and ungrounded. Please double-check that. In case the survey was conducted, and the data were collected and analyzed, so please write the methodology for that in the method section.
- In case the survey was not conducted properly, please remove this statement.

In conclusion, the performance evaluation of the Happy Seeder for sowing wheat crops in combined harvested paddy fields demonstrated its efficiency in terms of field capacity, field efficiency, and fuel consumption. The Happy Seeder proved to be an economical alternative compared to the conventional seed drill, saving costs per hectare. Farmers' positive reaction to the Happy Seeder highlighted its potential for adoption in sustainable agriculture practices, contributing to residue management and improved crop productivity. The successful field performance evaluation indicates that the Happy Seeder can play a vital role in promoting sustainable and eco-friendly agricultural practices in the Moradabad region and similar areas.

Comment [LH23]: This part should be mentioned in the conclusion section instead because it is already repeated in the conclusion.

CONCLUSION

In conclusion, the study evaluated the performance of the Happy Seeder for sowing wheat in combined harvested paddy fields, with a focus on addressing the challenges of crop residue burning and promoting sustainable agriculture practices. The results demonstrated the Happy Seeder's effectiveness in terms of field capacity, efficiency, and fuel consumption,

UNDER PEER REVIEW

making it a viable and eco-friendly alternative to the conventional seed drill. Moreover, the economic analysis revealed its cost-effectiveness, saving significant expenses per hectare. Farmers' positive reaction to the technology further supports its potential for widespread adoption. Overall, the study's findings emphasize the Happy Seeder's role in mitigating environmental hazards, improving soil health, and enhancing crop yields, thereby contributing to the long-term sustainability and prosperity of the farming community in the Moradabad region and beyond. Adopting the Happy Seeder can pave the way for a more environmentally conscious and efficient rice-wheat cropping system in the Indo-Gangetic region.

References

Bhuvaneshwari, S., Hettiarachchi, H. and Meegoda, J.N. 2019. Crop residue burning in India: policy challenges and potential solutions. International journal of environmental research and public health, 16(5), 832.

Bhuyan, A. 2019. Biomass management of rice straw–a case study of two districts (ludhiana and patiala) in punjab.

Kumar, D. 2015. Impact of laws for prevention of pollution from crop residue burning: In context to the State of Punjab.

Lohan, S.K., Jat, H.S., Yadav, A.K., Sidhu, H.S., Jat, M.L., Choudhary, M., Peter, J.K. and Sharma, P.C. 2018. Burning issues of paddy residue management in north-west states of India. Renewable and Sustainable Energy Reviews, 81, 693-706.

Parihar, D.S., Narang, M.K., Dogra, B., Prakash, A. and Mahadik, A.S. 2023. Rice residue burning in northern India: an assessment of environmental concerns and potential solutions–a review. Environmental Research Communications.

Patel, N.K., Rawat, R.B., Singh, S. and Mishra, V., 2022. Performance evaluation of turbo happy seeder: “A”.

Singh, J. 2018. Paddy and wheat stubble blazing in Haryana and Punjab states of India: A menace for environmental health. Environmental Quality Management, 28(2), 47-53.

UNDER PEER REVIEW

Singh, P., Gautam, B.S. and Yadav, R.K. 2017. Performance evaluation of happy seeder for sowing wheat crop in combined harvested. International Journal of Agricultural Engineering, 10(2), 643-646.

Singh, Y. and Sidhu, H.S. 2014. Management of cereal crop residues for sustainable rice-wheat production system in the Indo-Gangetic plains of India. Proceedings of the Indian National Science Academy, 80(1), 95-114.

UNDER PEER REVIEW